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ABSTRACT

This paper proposes three criteria for developing research questions that have the potential to illuminate the understanding of Web-supported learning in K-12 classrooms: (1) questions should be situated in progressive instructional contexts; (2) questions should focus on what is happening in the Web-supported learning environment in addition to measuring outcomes; and (3) questions should emphasize unique capacities of the Web as a tool or medium. These criteria are offered as a starting point for dialogue among researchers about questions sensitive to progressive education goals. A description of the variety of ways that the Web is being used to influence learning in K-12 classrooms includes introducing an example from a case study that typifies how most teachers currently use the Web within the context of their existing curriculum. Also reviewed are some of the major collaborative efforts between researchers and teachers to integrate cognitive tools and structured learning opportunities into Web-supported classrooms. (Contains 24 references.) (AEF)

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Using the WWW for Teaching and Learning in K-12 Classrooms: What Are the Interesting Research Questions?

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This paper proposes three criteria for developing research questions that have the potential to illuminate our understanding of Web-supported learning in K-12 classrooms. These criteria are then applied to a range of existing Web-supported projects that fairly represent how this technology is being used in classrooms today.

Web-supported Learning:
A Framework for Thinking About Research Questions

On the cusp of the 21st century, the World Wide Web continues to generate unabated fascination among the general public. It has become a ubiquitous and powerful tool for commerce, science, and individual interaction with the world. Education, however, finds itself in a familiar place with regard to technology-- struggling to develop pedagogy and curriculum that can take advantage of its rapid advances.

The logistical task of linking the nation's classrooms via telecommunication networks, although formidable, is substantially simpler than understanding how to use the tools of technology effectively, and implementing quality learning experiences in these classrooms. The latter requires a deep understanding of the educational goals and the limitations associated with the use of such tools in classrooms, as well as the skills and support structures to develop materials, train teachers, and implement these ideals (Songer, 1996).

These challenges can be summed up in the question, "How are technologies best used to realize high achievement standards and to prepare students for the world they will enter when they leave school?" (Hawkins, 1996). Researchers have responded with a range of investigative projects, some of which have examined how teachers and students use the WWW within the context of existing classroom practices, and others that have

studied the introduction of supportive cognitive tools and new learning paradigms into Web-supported classrooms.

Good research questions, of course, drive these investigations. Research questions and the theoretical frameworks from which they are derived give direction to these studies, imply certain methodologies, invoke conceptual perspectives to be privileged, dictate what one "pays attention to" and what one ignores.

With regard to the World Wide Web, researchers must ask themselves: What characterizes "interesting", "productive", or "illuminating" questions? Admittedly there are no universal standards for such questions. However, I offer the following three criteria in order to initiate a thread of discourse about the direction of inquiry in Web-supported K-12 classrooms. It is up to the research community to determine whether these criteria are necessary, sufficient, moot, intellectually liberating or myopic.

1) *Questions should be situated in progressive instructional contexts.* We must link research questions with the progressive ideals of promoting autonomous learners, the push for students to collaborate effectively with others, to pose problems, gather evidence, construct arguments effectively, and to produce authentic, complex products and performances. These ideals suggest fundamental changes in the traditional classroom culture, where teachers "send" and students "receive" prefabricated ideas, and where knowledge is someone else's finished product. In progressive classrooms, planning, activity, and dialogue are the shared domains of teachers and students; teachers are facilitators of learning and provocateurs, rather than the hub of authoritative discourse.

What is the role of the Web in this kind of classroom? It is *not* a place for students to find "right answers"; rather it is a tool to gather information that can be used to build ideas. It is also a medium which is capable of supporting widespread learning communities that extend beyond the classroom. The Web can help us better conceptualize learning as participation in a community of practice as opposed to learning as the acquisition of unambiguous facts and concepts (Brown & Campione, 1994; Sfard, 1998). In fact,

researchers must be vigilant about how the marriage of technology and progressive instructional approaches alters the concepts that define what they study. What do we now mean by "learning", "collaboration", "inquiry", "tool", or "teaching"?

2) *Questions should focus on what is happening in Web-supported learning environments in addition to measuring outcomes.* Much classroom research is of the black-box variety. Inputs are operationally defined (e.g. learner characteristics or instructional interventions), learning experiences occur (unexamined), then the outputs are measured (e.g. objective achievement tests, post-hoc interviews, etc.). Alternatively, what occurs *during* the learning activities should be of greatest interest and utility to researchers, and would reveal *why* rather than simply *if* certain learning contexts are more robust than others. Because the integration of progressive instruction and Web-based experiences is a relatively novel event, and typically includes collaboration, dialogue, and acts of construction, it is imperative that we understand what kind of action is taking place during these activities. This means examining relationships between people, not just between variables, and conducting investigations where the unit of analysis is a group of learners, an entire class, or even an extended Web-supported learning community comprised of students, teachers, community members, and on-line disciplinary experts. The notion of the learner as an isolated processor of information is rapidly being replaced by the idea of the learner as a social being, co-constructing knowledge with others.

Because technology, when used to its best advantage, helps reshape roles for teachers and learners, and encourages new and different types of interactions in the classroom, qualitative approaches such as ethnographies or case studies should be considered to investigate these phenomena (Fetterman, 1989; Patton, 1980).

This is not an appeal for a focus on a particular aspect of Web-based learning, but rather a suggestion that research methods act as lenses to reveal or obscure, and that drawing upon a variety of methods can help clarify phenomena that are not interpretable using a single paradigm.

The qualitative tradition of investigating research spaces using grounded theory would add valuable context to what is learned from the more theoretically constrained approaches of investigations based on instrumentation and identification of significant differences. Qualitative approaches often emphasize discovery of-- rather than verification of-- theoretical positions (Fetterman, 1989; Wolcott, 1988). Novel learning environments, such as those integrating the WWW with progressive instructional practices require researchers to describe at various levels what is happening to the participants. To an extent, these processes require some predetermined theoretical positions if only to provide a utilitarian vocabulary and a rudimentary framework from which to view action. However, an overemphasis on the confirmation or disconfirmation of hypotheses may blind us to subtle but powerful patterns of activity that characterize social environments such as classrooms (virtual or real). In a technical sense, we must sensitize ourselves to a broader bandwidth of thinking.

With respect to the ideas above, learning is de-coupled from information access and new questions emerge: "How are social constructs such as authority or cooperation affected in classrooms where learning is based heavily on Internet resources?", "How do virtual social groups form as a result of telecommunications?", "What gives coherence to these groups and are they qualitatively different from groups formed in the real time and space of the classroom?" These questions and the suggested methods described above are not necessarily new to education, but they are not currently being applied with sufficient vigor or frequency.

3) *Questions should emphasize the unique capacities of the Web as a tool or medium.* What distinguishes the Web from other instructional technologies? This is a difficult question because many capabilities of the Web are simply extensions of existing software capabilities; correspondingly, many of the advantages of using the Web are matters of efficiency and scope rather than of unique affordances that could fundamentally alter relationships among learners, teachers, and the curriculum. Research on multimedia, for

example, has already contributed to our understanding of how students use hypertext to navigate in virtual space (Anderson-Inman, 1989; Conklin, 1987) and how individuals learn from computer-based text, images, and sound (Park & Hannafin, 1993). Rather than looking at aspects of learning from the Web that are extensions (efficiencies) or redundant qualities found in other types of software-supported learning environments, more productive queries may be directed at examining entire Web-supported pedagogical approaches to teaching and learning (described later). Because the Web provides access to information, the focus should return to the students and how they use, share, and learn from this information-- especially with regard to information that is unique to the Web, search processes that are unique to the Web, and human interactions that are affected by Web use.

Such unique characteristics of the Web include on-demand access to large amounts of data (such as U.S. Census Bureau data), availability of original documents (such as scans of newspapers or personal letters), artifacts (such as historical photos or images of art works), information on special topics that cannot be found in conventional resources, information about events occurring in real-time (such as weather, unfolding international news stories), and perhaps most importantly, the ability for learners to communicate with others. This communication can take the form of sharing scientific data with other schools by posting local data on a common Web site, or e-mailing students, community members, and disciplinary experts, thus creating learning opportunities that transcend the traditional time/location boundaries of institutional learning.

In summary, these three criteria-- that research questions should: 1) *be situated in progressive instructional contexts*, 2) *focus on what is happening in the Web-supported learning environment in addition to measuring outcomes*, and, 3) *emphasize unique capacities of the Web as a tool or medium* -- are not meant to champion certain investigative agendas or marginalize others. Rather, they are offered as a starting point for dialogue among researchers about questions sensitive to progressive educational goals.

Research questions, however, are always situated in some learning context and must be "tuned" to the opportunities that present themselves in that context. In the following sections of this paper, I describe a variety of ways that the Web is being used to influence learning in K-12 classrooms. I first introduce an example from a case study that typifies how most teachers currently use the WWW within the context of their existing curriculum. I then review some of the major collaborative efforts between researchers and teachers to introduce cognitive tools and structured learning opportunities into Web-supported classrooms. In the process of reviewing these examples, I suggest research questions that seem promising within the context of the classroom situations described.

Teachers Using the Web In Their Existing Curriculum

In a recent national survey of Internet use by teachers, Becker (1999) found that the most common way for teachers to have students use the Web is to gather information for research reports. In fact, in the past two years, "Web searching has become the third most common use of computers by students at school after word processing and the use of CD-ROMS" (p. 6). In these search situations, students are seeking the "raw material" from which they will construct knowledge. This raw material includes information in the form of statistics, audio clips, or images, and original document such as letters, newspapers, research reports or photographs.

In a case study of a Seattle elementary school in which all the upper-level students have laptop computers, Windschitl and Sahl (1999) describe a Web-supported social studies classroom:

> Students in Melinda Smith's 6th grade bustle into the classroom, open their laptops and begin background research for their social studies project before she even enters the room. Some of them attach wireless modems and begin searching the WWW. One young girl focuses back and forth between the Web and an organizational chart she has made with her word processor. She

> realizes that, for her research on Egyptian civilization, she needs to gather certain "Web" artifacts. By the end of the period she has downloaded images of the Sphinx, sound clips of Egyptian music, and maps of the Nile River Basin. Ms. Smith moves from student to student eliciting their reasoning about why they've chosen to include certain information in their research report. Contrary to conventional concerns about students and the Internet, these students first use the CD ROM encyclopedia to find information ("it's more reliable" quips one student), then try to find print resources in the library, and finally venture out onto the Web, using surprisingly sophisticated search strategies and skepticism to extract what is useful and valid from the ocean of information. These savvy students know just where to find government databases, images, charts and graphics and original documents; they know "what kind" of information is more easily found on the CD ROM encyclopedia and how to e-mail individuals anywhere in the world who might be good references for their research papers (p. 16).

The students in this case study developed impressive strategies for finding information, and certainly a researcher could ask: "How effective are individual search strategies?", but perhaps more interesting questions would refer to the students as a group: "How do effective searching strategies diffuse through the social networks of the classroom?", "Do groups of students consensually determine the validity of certain sources of information?", or, "How are students underlying epistemologies influencing or influenced by their interaction with large amounts of initially unorganized material?"

Interestingly, the media center coordinator at this school reported an increase in the students' use of printed material, prompting the questions: "Do learners see some new-found value in editorially-filtered information and coordinate its use with sources from the Web?" or, "Are teachers changing their curriculum to include more research-based learning activities?"

Collaborative Efforts Between Researchers and Teachers

Perhaps the most interesting cases of Web-supported learning come from collaborations between researchers and educators. In many such cases, researchers work with educators to develop special software tools that help students use the Web more effectively. These tools (often Web-based themselves) help students organize and make sense of information they find, and provide cognitive scaffolding for students to participate in complex learning tasks. The design of these cognitive tools goes hand-in-hand with the instructional design of learning tasks that are not easily accomplished without the use of the Web. In the best case scenarios, teacher and student roles, the goals and objectives of learning, and the assessment strategies are all coordinated-- not driven by-- the technology. With or without teacher-researcher collaboration, this kind of Internet use is not common; fewer than 7% of teachers involve their students in cross-classroom projects or Web-publishing (Becker, 1999). The potential for meaningful learning in these contexts, however, is significant enough to warrant on-going investigations.

In one such project, Kids as Global Scientists (KGS), students develop an understanding of weather patterns by doing independent research on the WWW and sustaining meaningful dialogue with peers in different locations (Songer, 1996). In the first part of the curriculum, the research phase, students collect information from a variety of sources including hands-on data collection and download relevant information from the WWW; they also question local weather experts who are, in most cases, atmospheric sciences majors at local universities. In the second, or exchange phase, students send ideas to peers in different locations around the country and are encouraged to generate inquiry questions on topics of special interest to them. Students eventually collect a range of materials that enhance their understanding of the chosen topic. Learning culminates in a final group portfolio that summarizes the activities performed and knowledge developed by all group members.

For the researcher, the major goal of this work is the exploration of learning potential-- the study of students' knowledge development as it progresses from less articulate and less integrated understandings to increasingly complex forms. This learning includes not only content understandings, but motivations about self-regulated learning and emergent learning properties. This project is also premised on the notion that technology should make some unique contribution to the learning environment. With regard to the WWW, these features include immediate access to large amounts of up-to-the-minute information, multiple representations of information (text, images, graphs, sounds, video), access to unique "special interest" information, and, connections to individuals outside the classrooms who could potentially be collaborators in learning (other students, other teachers, disciplinary "experts", community members, educational researchers).

Other large-scale projects have, as explicit goals, the development of learners as participants in the discipline they are studying, acting more like scientists, for example, than science students (Shrader & Gomez, 1997). The CoVis (Collaborative Visualization) project of Northwestern University has developed a suite of Web-enhanced science curricula, ranging from global warming to water purification, for high schools. The curriculum combines computer-based inquiry tools, advanced scientific visualization software now used by scientists, project-based pedagogy, and national broadband links to scientists and to the Exploratorium in San Francisco. The curriculum transforms classrooms into laboratories of inquiry that are much closer to the methods of scientific work than is typical of most high schools.

Another Web-based project, the Knowledge Integration Environment (KIE) helps students understand the conventions by which knowledge is constructed by scientists, historians, and mathematicians, according to rules of argument and validation accepted by these special communities (Linn, Bell, & Hsi, 1998). The project enculturates learners into the language, practices, and ways of thinking in the discipline they are studying. In Berkeley, California, high school students work with a Knowledge Integration

Environment project that presents them with a complex, real-life dilemma facing scientists--What is causing a dramatic rise in the number of deformed frogs in the United States? The site suggests several arguments that have been forwarded by different groups of scientists, including chemical pollution, parasites and changes in the temperature of lakes and rivers. Students deliberate in class about how arguments are developed from data and what kinds of arguments are scientifically valid. They then explore a number of Web sites connected to the KIE page and begin to gather relevant information from which they will construct arguments for or against different hypotheses.

The KIE Website offers cognitive support with on-line notebooks to organize student thinking, Web-authoring tools for students to create their own Web pages, and database tools that allow students to assemble collections of individual pieces of evidence. Gathered evidence may include biological and environmental statistics from several sources, observations of field researchers and laboratory scientists, and artifacts such as x-rays of deformed frogs. Young learners join with scientists in gathering, triangulating, and evaluating information from multiple sources to engage in an authentic problem-solving task.

Another type of Web-supported project is CSILE™ (Computer Supported Intentional Learning Environment), a network that provides support for collaborative learning and inquiry in school environments. Its core is a community database that contains graphics, text, and links to other media. Students connected to the network can read from elements called "notes", and, using certain rules, can edit the notes. Participants can link notes to any organizational framework, producing an interconnection of notes on a particular topic or issue. A number of controlled studies have demonstrated that students who engage in knowledge-building with CSILE excel in the quality of questions they ask, exhibit greater depth of explorations of concepts, and have more mature beliefs about learning (Scardemalia & Bereiter, 1996; Scardemalia, Bereiter, McLean, Swallow & Woodruff, 1989).

These four examples of large-scale projects have common themes in that they all foster the construction rather than the reception of knowledge, they provide students access to data in a variety of forms, they use collaboration in the classroom as well as between classrooms, they link students with professionals in the field, and they provide the technological tools to help students engage in complex thinking.

Valuable research questions abound in these kinds of scenarios: "How do students adapt to their roles as independent, yet collaborative learners?", "What emergent learning situations arise from the geographical distribution of students?", "How has the role of the teacher changed?", "Does this kind of technology use have unforeseen effects on students' learning when they leave these classrooms?" These are just a sampling of the kinds of questions available to researchers-- questions that examine more than achievement scores or time on task. Even so, they are perhaps best viewed as "seed questions", places to start thinking about even better queries.

Studying Communication with Others

Instant aecess to information is one attractive feature of the WWW, another is its global domain. The novelty and excitement of accessing Web pages from places like France or Malaysia is stimulating for learners. Students in many classrooms routinely use e-mail and newsgroups to communicate with students abroad for a variety of purposes. Some of these communications are part of the wide-area research collaborations described earlier; some are one-to-one partnerships in which individual students from different locations share interesting ideas, such as high schoolers in Israel and southern California comparing the ways in which their communities conserve water, or students in Poland and Great Britain discussing how their countries' respective economic situations have affected their personal lives.

Bonk, Appleman and Hay (1996) describe how computer-mediated environments such as the Web, e-mail, bulletin boards and computer conferencing have broadened the range of audiences and viewpoints available to students and they have posed important questions

related to this phenomena: "How might these tools encourage learners to explore and accommodate alternative viewpoints?", and, "How does one gain a greater sense of intersubjectivity and common ground through computer technologies?" These kinds of questions expand the research agenda beyond the intellectual promise of these interactions, so should we not investigate changes in these students' values, attitudes, and beliefs about the rest of the world? When students study abroad, parents and teachers hope that they return with more than an academic understanding of the host countries. A major purpose of exchange programs is to cultivate a deep appreciation of other countries, their cultures and their people. This implies a fundamental change in how students perceive others, what they believe about other cultures and how they revise their worldview. Internet-based activities in which students ultimately develop relationships with students in other cultures should have some influence on the learners' sense of the world (Sugar & Bonk, 1995). Of course, these influences do not always explicitly manifest themselves; finding meaningful measures of nuanced changes in values, attitudes and beliefs is always challenging. But as teachers and students participate in electronically-mediated internationalization of classroom experiences, researchers should investigate how (virtual) global experiences influence these characteristics of participants.

This article has focused, so far, on phenomena surrounding the receipt of information. The complement, then, of accessing information compiled *by* others is producing communicative digital materials *for* others. We know that there are significant positive effects of writing for an audience as opposed to writing for ones' self and that this includes e-mail as well as conventional forms of composition (Cervantes, 1993; Gallini & Zhang, 1997; Graves, 1983; Levin, Waugh, Rogers & Smith, 1989). Studies of communications in e-mail environments also suggest interesting differences in comparison with print forms of communication: less structured, less constrained by social conventions, more spontaneous (Kiesler, Siegel & McGuire, 1984; Zuboff, 1988). Are these effects sustained or perhaps amplified when students compose material for publication on the Web? Do

students develop some digital palette from which they incorporate icons of meaning into their messages? How are these icons shared or interpreted by others? Can students develop new ways of communicating meaning with the digital tools available to them in the medium, perhaps using Java scripting or other digital tools (Shank, 1997)?

Conclusions

Technology will need to play a substantial role in creating the conditions of effective learning for all children. To make this possible in schools, we will need to take advantage of the rapid evolution of telecommunication and multimedia strategies. Our responsibility as researchers is to develop the potential of such information-rich, distributed environments, framing those questions that both define and reveal what learning can be. This paper is intended to begin a public, on-going dialogue about such questions; hopefully others in the research and teaching communities will contribute to this important conversation.

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